Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554
20 August 2003

In the Matter of Inquiry	)	
Regarding Carrier Current	)	
Systems, including Broadband over	)	ET Docket No. 03-104
Power Line Systems	)	

REPLY COMMENTS OF CORTLAND E. RICHMOND, Jr.
to
Reply Comments of PowerComm Systems, Inc., dated 20 August , 2003

These are Replies of Cortland E. Richmond, Jr., in answer to Reply Comments of PowerComm Systems, Inc., in this document referred to as PowerComm, in the matter above, dated 7 July 2003.

The writer has been involved in EMC and EMI engineering since 1983, spent 21 years in the United States Army working with airborne and ground communications equipment, and has been an Amateur Radio operator since 1958.

These replies take the form of excerpts from the PowerComm's Reply Comment, noted as Comment, followed by the writer's remarks, noted as Reply. A Roman numeral annotates each Comment and Reply. Replies commence below.

I

Comment:
The ARRL in their Comments to the NOI pointed out some problems they have experienced with RF noise radiating from distribution circuits. This has been a problem even before Access BPL is introduced, and the suggestion is that Access BPL will tend to make this problem worse.
From our experience of observing noise from many utility circuits, there are noise problems that need fixing. We have observed noise, that shows up while probing the circuit with our couplers and simultaneously observing radiated emissions with an antenna, and the combined observations point to the conclusion that the noise is from the utility plant. The following recordings taken from power lines demonstrate the problem.

Reply:
PowerComm acknowledges that its service hinges on a control of electrical noise on utility transmission lines. The premise it urges the Commission accept is that utilities will be better actors in this respect than they have been in the past.

II

Comment:
10. Access BPL deployment will help solve these and other similar problems. PowerComm Systems has examined each distribution circuit for noise quality prior to making connections with BPL equipment. In the cases shown below, we had to explain that the noise was too severe for our BPL system to work effectively, and that the utility needed to take corrective action. So, to the contrary, BPL deployment can actually help identify and solve noise problems originating from electric systems which decide to deploy Access BPL. It will be in everyone.s best interests to clean up these spectrum polluters.

Reply:
The clean-up PowerComm admits is needed is the result of decades of underinvestment in maintenance. The cost of fixing it will come out of BPL profits -- if any.

III

Comment:
The energy of the impulse is concentrated near 20MHz and tends to dominate the HPA band from 4 to about 21 MHz. Other signals seen in the spectrum are TV Channel 6 at 83 MHz, the FM band from about 87 up to about 107 MHz, and TV Channel 12. Notice the relatively empty spectrum from about 40 MHz up to about 82 MHz. This entire band was unused in this region of power company operation. This spectrum could possibly be used for an access BPL application in this particular service area. (Figure 4. Spectrum of Noise Signal of Figure 3.)

Reply:
PowerComm identifies a potent HF spectrum interferer. It misidentifies as available spectrum a region which in which its scan carriers above an instrument and/or background noise level of about 300 microvolts were not seen. But PowerComm cannot claim that spectrum is empty. 300 microvolts is a more than substantial signal for that spectrum, and most users would not be seen; signals identified as FM broadcasters are 25 to 35 dB above the 40-50 MHz noise level it claims is unused, and as FM broadcasters typically use in excess of 10,000 watts power. it is therefore almost certain that the instrument employed would fail to detect VHF-low-band spectrum users in the area.

Comment:
PowerComm Systems has made power line emissions measurements has attempted to determine Access BPL operations that comply with the existing FCC Regulations and Measurements standards. We have attempted to perform our measurements and analyses consistent with interpretations of the Rules presented in the recent EPRI report number 1001891, .The Possible Use of the Electric Power Transmission/ Distribution System as a Waveguide for a Wideband Communications System., November, 2001. The interpretations used to define the broadband communication system in the EPRI report separates operation by frequency around 30 MHz. Below 30 MHz the problem is equated with that of a Carrier Current System and treated as a non-intentional radiator. Above 30 MHz the problem supposedly should be interpreted as a Class A Digital Device. Under these interpretations it is further indicated in the EPRI report that the measurements for emissions would be made with a receiver with 9 kHz bandwidth below 30 MHz, and with one of 120 kHz bandwidth at or above 30 MHz. We believe these represent the most prevalent interpretations of the FCC rules and test methods.

Reply:
Measurements made to FCC Part 15 limits are often interpreted according to a distinctions between 30 MHz and below, and 30 MHz and above, as well as Class A digital and Class B digital, etc.. However, these distinctions do not and should not be applied to the transmission lines from which the majority of Access BPL's radiation would occur. In these cases, measurement should be as against the probability of harmful interference to the radio user. The majority of radio users in the 2-50 MHz spectrum relying upon received signals on the order of 1 to 10 microvolts, and often less, Part 15, thogh in the past a useful tool, is in fact not adequate to predict interference from BPL.

Comment:
Prior to making field measurements on the energized power line, a power line lab model was created and tested for emissions for reference. The model consists of two six-foot pieces of AWG2 ALS separated vertically by 42 inches. This model intends to simulate a medium voltage single phase line rated for operation typical of systems with 10kV to 15 kV phase to neutral. To interface RF signals with the line, unique couplers based on lightning arresters are mounted on each end of the model. A special terminating load with resistance approximating the characteristic impedance of the power line is placed across the artificial line in order to make it appear very long. Signals were injected at one end and received from the other in order to measure the gains of the couplers. This .artificial line. was driven with QPSK data signals at 54 MHz, with bandwidth of 1MHz, and the antenna was used to monitor emissions from the line and couplers. The antenna was oriented parallel to the line and at a level horizontal with the middle of the line. The antenna was located at various distances away from the line and output voltages were recorded. Calculations were made to result in E-field measurements versus distance. The results of these measurements were that the small artificial line with couplers exhibited a nearly ideal log-linear response over the full range of distances, or log E varied as 1/d, as expected for far field radiation. The voltage input to the coupler was set such that the electric field intensity from the model line was about 30 microvolts per meter at 30 meters. The resulting plot of radiation versus distance for this simulated line is plotted for reference and comparison with the data from various configurations of energized power lines, as will be shown and discussed below.

Reply:
PowerComm semms ot have attempted before making its arguments to determine if its arguments would in fact be tenable. However, the setup it undertook in order to do so seems designed more to support its argument than to test it. 6 feet is far too short a transmission line segment for a meaningful test, and the structure PowerComm describes appears to be one that radiates most efficiently polarization orthogonal to the measurement antenna orientation it selects. In addition, the location selected for the measurement antenna is at a null for radiation from the differentially driven radiating structure. It does no realistically simulate the actual orientation of power lines, which PowerComm later in its remarks notes does transition along the span from vertical to horizontal. Moreover, it scales poorly to both the size of actual distribution lines and frequencies PowerComm and others propose to use. This may have influenced subsequent measurement, which does not render those measurements more convincing, but less.

VI

Comment:
Since the real power lines are very large compared with the wavelengths of the RF signals to be used with BPL systems, behavior of their radiation patterns are hard to predict. In order to determine the likely behaviors and to establish transmit power limits for BPL systems with respect to emission limits, radiation measurements were made from several three phase power line geometries: box, horizontal, vertical, and triangle over neutral. Another important aspect of these measurements was to establish the reach of the near field from the large power lines, and determine the likely distance for standard measurements to ensure that true far field radiation is measured. This will be seen in the E versus distance plots below as compared with the reference curve obtained from the artificial line. Initially, transmit signal level is set at the value required to drive the artificial line to obtain 30 microvolts per meter at 30 meter distance.

Reply:
The Commission should not, in considering these measurements, be distracted from its responsibility to prevent harmful interference to licensed services. 30 microvolts per meter at 30 MHz (see below) represents, with a 0 dBd gain receiving antenna, a signal in excess of 30 microvolts at the receiver. This is enough to capture an NBFM receiver, preventing reception of the desired signal, and more than enough to cause harmful interference to AM and SSBSC modes.

VII

Comment:
The figures below show one set of measured radiation versus distance data taken at 30MHz from the 13.8 kV distribution circuit. This set is for the horizontal configuration of the power line. Each curve results from applying the transmitter to a single phase one at a time. It is clear that the radiation pattern does not become log-linear as compared with the artificial line response until near 20 meters. This means that at closer distances, measurements are affected by near field as well as radiation field. Near field energy is reactive in nature and varies as 1/d2 and 1/d3. This represents inductive and capacitive effects of the power line circuit and the energy of this field stays near the power line. It is clear from this that measurements can not be made within 20 meters of the power line and be representative of radiative emissions. Extrapolation factors for change of distance are not applicable within 20 meters of this line for the horizontal configuration. This distance varies with power line configuration.

Reply:
The selection of 30 MHz for PowerComms' measurements is unfortunate. As PowerComm notes, at 30 MHz, it does not see a drop to far-field numbers until some 20 meters from the 13.8 KV line. This indicates a similar transition at 3 MHz at some 200 meters from power lines. And this is when using an antenna orientation less than maximally responsive to radiation from the line.

VIII

Comment:
Because of the measurement bandwidth change defined at 30 MHz from 9kHz to 120 KHz, an abrupt change occurs in the definition for radiated emissions limits for broadband signals. For broadband signals with spectra spanning this arbitrary frequency, some abrupt penalties kick in. The
transmitter spectral density must be decreased abruptly by 11.3 dB for signals at 30 MHz and above in order to maintain the same total emission intensity value as below 30 MHz. This is a severe penalty for the broadband communications system due to the Test standards. The FCC measurement standard should be revised to account for emissions from broadband signals with spectra crossing this artificial boundary defined at 30 MHz. The measurement standards need to be revised for use of broadband signals of BPL systems and specified in terms of E-field density, rather than a fixed intensity with bandwidth of the receiver specified, and changed abruptly at some arbitrary frequency. In addition, to account for the expected easier radiation by higher frequency signals, the E-field density should be specified as a function of frequency. A specification limit for E-field density as an inverse log-linear function of frequency seems appropriate. This requires more study.

Reply:
The writer understands the selection of 120 KHz as measurement bandwidth above 30 MHz was to protect services using wider bandwidths above 30 MHz than below. It may indeed now be appropriate to use measuring bandwidths more closely aligned to those in use by the services Part 15 protects, though not as part of the BPL proceeding, but rather as part of a modernization of RFI protection generally, and perhaps internationally. The Commission certainly would not wish to at this point disassociate itself from international agreements and understandings to improve trade by harmonizing interference standards. However, the effect of a pervasively higher level of interference than is presently permitted under Part 15 , as requested by BPL proponents, would be very likely to have a detrimental effect on US technology exports to nations with a more careful approach.

IX

Comment:
Because of the reach from the power line to between 20 and 30 meters of the reactive or near field, the Digital Device emissions test may not apply. The test specification is defined for measurements to be made at a distance of 10 meters. Extrapolation to 30 meters is not valid, so before future BPL systems are developed for operation above 30 MHz, new rules must be written.

Reply:
Using PowerComm's logic, and given that the reach of the near field is properly measured in wavelengths, not feet or meters, it seems obvious that before BPL systems are developed for operation <u>below</u> 30 MHz, new rules must be written. The near field at HF frequencies may extend several hundred meters or more from the power line, instead of merely 20 or 30 meters.

X

Comment:
Measurements were taken of E-field intensity directly under the power line starting at the substation and going out along the line. The line starts out in the box configuration and goes through transitions immediately, so that at the first pole about 90 meters away, the line conforms to a horizontal configuration. From the figure below it can be seen that the E-field intensity drops by 10 to 15 dB at 30 MHz within 60 meters of the starting pole. These decreases are not due to line losses, but are much more likely due to distancing from the couplers as hot spots. A strong case can be made for the couplers as near field hot spots that may be worked to improve radiation performance.

Reply:
The writer notes that one might extrapolate this to predict 3 MHz emissions as strong as one third of the Part 15 limit 600 meters from a power line. In areas where overhead power lines are in use, few residences are even this far from one.

XI

Comment:
Additional data was also taken at finer spacings along under the line. Samples were taken at 2 meter spacings at distances of 120 to 150 meters from the couplers at the substation. Standing wave patterns are obvious in the data. The voltage maxima and minima observed varied by about a 3 to 1 ratio at 30 MHz with periodicity of 20 meters. No other .hot spots. were observed along the line. In fact the signal level falls on the lossy line and the E-field falls off in proportion versus distance along the line. The horizontal configuration data was taken starting near a voltage maxima under the
distribution circuit.

Reply:
The suggestion here is that it is possible a 3 to 1 increase (almost 10 dB) in emissions might be observed, depending on one's distance along the line from a coupler. If so, it seems possible that at 3 MHz, harmful interference may exist up to 1800 meters from the power line. This certainly merits more study before widespread deployment goes ahead.

XII

Comment:
It is appropriate to compare these plots from those reported as simulations from the ARRL. It will be seen that measurements of E-field intensity along the power line vary as standing waves. However, the ARRL model of a lossless line over earth is not consistent with the measured results. The line must be seen as a lossy transmission line. Paths to earth should not be assumed to exist, unless they are modeled as high impedance at the RF frequencies. The transmission line should be assumed to be driven from one end, as the opposite path direction is blocked by high loss, impedance matching filters. The transmission line should be terminated in its characteristic impedance in order to simulate a long line. The coupler must also be modeled correctly, as it is the largest source of field intensity in the system, forming a hot spot that has a large reactive field with limited radiation reach. This has been observed repeatedly and is one of our areas for continuing research.

Reply:
Again the choice of different frequencies for simulations and measurements renders results less than directly comparable. Certainly a lossy transmission line will affect a simulation, but losses from a line spaced as widely as PowerComm's putative line to neutral system occur mainly by radiation., the very source of harmful interference, and PowerComm has not addressed longitudinal conversion loss, which is indeed expressed as a line to ground source, and vertically polarized, which its instrumentation appears nor to have been set up to detect.

XIII

Comment:
The Home Plug Alliance In-House BPL modems use transmit power densities of
-55 to -50 dBm per Hertz. Previously, as reported in Appendix A, it was estimated that transmit power level for Access BPL systems might be around .60 dBmW per Hertz. This was based on previous standards work in defining the VDSL TelCo communications method, which will operate over unshielded, non-twisted phone cables with carriers up to 30 MHz. Based on emissions measurements from overhead distribution circuits, lower channel capacities result for the transmit power density limits of .65 dBm/Hz, and .80 dBm/Hz above 30 MHz.

Reply:
TelCo quality wiring has an inherent radiation loss many times lower than that of power line pairs. One might expect 30 dB lower , or even better, levels of interference from a VDSL signal than from BPL using the same spectrum. Conversely, absent preferential regulatory treatment, one could not expect similar speeds of service from BPL as VDSL might provide. This may have some adverse impact on its financial success.

XIV

Comment:
The capacities reported here are based on a single noise profile from a Rural setting. Whenever an Urban noise profile is used, with several of the VHF bands occupied, e.g. Nashville, TN, with channels 2, 4, and 5 active, and with many more licensed bands in use, the data capacities become much less. Considering that loading of distribution circuits is also greater, data rates per customer become even lower. Access BPL becomes marginally competitive with other broadband Internet services in many Urban settings. Improved Utility service is still another matter however, and since Access BPL is perhaps the only cost effective means of gathering AMR information and providing load management into homes, Access BPL still is a needed option in Urban areas.

Reply:
If the rural noise profile is used to protect rural radio spectrum users, who include military, government., emergency services and others, many of whom locate there in order to avoid radio interference, it can be seen that protecting rural spectrum users will be more difficult than protecting urban ones who already contend with higher noise levels than rural users do.

XV

Comment:
The ARRL in their Comments to the NOI pointed out problems with RF noise radiating from distribution circuits. They are of the opinion that Access BPL deployments will cause this problem to worsen. Noise sources will be much easier to identify, locate, and clean up with an Access BPL system in place. An Access BPL deployment would identify these noise problems. The BPL system vendor would by necessity help identify the sources of the noise, and help the utility to clean up these problems before deployment of a system. Further, once a system is in place, it is highly likely that degradation of performance of the BPL system will trigger a search for the cause.

Reply:
Noise sources may have to be identified to make a BPL system <u>work</u>. BPL will, however, so far form improving things, aggravate them, by providing a continuous source of RF where an often sporadic one existed before. Moreover, it is quite likely the degradation in BPL performance PowerComm mentions will be due to a transmitter being operated at the higher power needed to penetrate interference from BPL.

XVI

Comment:
Based on measurements of emissions from several geometries of three phase circuits we have shown that power spectral densities of .65 dBm per Hertz for Access BPL signals satisfy existing FCC rules for carrier current systems. We explain how both In-house and Access BPL systems, which conform to the HPA transmit spectral mask, intelligently avoid interference by turning off selected carriers of the multi-carrier transmitters.

Reply:
The measurements mentioned have shortcomings which render them less useful than PowerComm asserts. More study will be needed before all parties begin to agree on the magnitude of the problem BPL poses, or even that a problem might exist. .

XVII

Comment:
Based on measurements of emissions from several geometries of three phase circuits we have shown that power spectral densities of .65 dBm per Hertz for Access BPL signals satisfy existing FCC rules for carrier current systems. We explain how both In-house and Access BPL systems, which conform to the HPA transmit spectral mask, intelligently avoid interference by turning off selected carriers of the multi-carrier transmitters.

Reply:
The writer disagrees that the levels measured are representative of interference to be expected from deployed BPL.. In addition the purported ability to avoid interfering by masking certain portions of the radio spectrum is not sufficiently adaptive to protect all who require protection.

XVIII

Comment:
We agree with the UPLC in its Comments to the NOI that first generation Access BPL systems can satisfy the current FCC rules for radiated emissions. Based on measured emissions and comparison with all present rules, PowerComm Systems believes its system, which makes use of HomePlug Alliance compliant transceivers both for in-house and for access devices, complies with rules governing Current Carrier Systems. However, future BPL systems operating at frequencies above MHz are not covered by present Current Carrier System specifications, and the Digital Device specification will not apply due the 10 meter testing distance.

Reply:
It is indeed possible that Access BPL and Home-BPL systems can satisfy existing Part 15 limits for radiated emissions. However, an unbiased examination of the physics of the situation leads this writer, among others, to assert that BPL's compliance Part 15 is not a guarantor of protection from harmful interference, but an assurance that harmful interference will occur. Part 15 was not meant for an application of BPL's pervasive omnipresence.

XIX

Comment:
Existing FCC definitions, equipment classifications, and measurement standards were not written with this application in mind. Perhaps a new class of service should to be defined for the Broadband Power Line Communications Systems that will operate over the medium voltage distribution circuits and over the low voltage drop wires into the customer premises.
This is especially a problem for next generation systems operating at and above 30 MHz.

Reply:
Here PowerComm agrees with this writer. However, far from creating a new radio service out of BPL, in view of its impact upon existing radio users the technology should be permitted to mature until a less obtrusive presence may be developed. BPL's apparent convenience is a costly illusion, the Commission should not be too quick to embrace.

XX

Comment:
Broadband Internet access for Rural Americans will be most cost effectively provided through communications partnerships with the Rural Electric Co-operatives. Broadband communications over the existing power line can reach virtually all communities and homes in America. The FCC can be pro-active in making this happen in several ways. Since the costs of regeneration are the key to system deployments in rural areas, efforts to control these costs could be taken. Presently, regenerators are required about every half mile.

A BPL system backbone can be deployed at a rate of a mile per hour per bucket truck and line crew. Present day systems can be deployed at under $2k per mile or less than $200 per customer passed Increased transmit power density is needed for greater system reach before regeneration. New rules could provide relief of the radiation density allowable in Rural areas. The first generation BPL systems that can serve hundreds of homes will be limited to a fraction of a milliwatt of transmit power. Transmitters for individual Amateur radio operators on the other hand are afforded watts of power.

Reply:
The cost of repeaters (each of which radiates as strongly as a service coupler, and over a comparable radius) may indeed drive BPL costs. Even urban deployments , as in Germany, have required installation of repeaters to provide satisfactory service. This bodes poorly for the success of such systems. Moreover, in view of the interference problems BPL deployment is already causing, and would cause, further relaxation of emission limits to avoid one or two repeaters seems a less than reasonable accommodation.

XXI

Comment:
It should be pointed out that with proper choice of modulation method, such as DMT and FDM, or OFDM, it will be possible to easily control spectral densities used by the BPL communication system, and to comply with the non-interference with existing licensed services. This is possible due to the fine control of carriers at resolutions as low as 200 kHz as for the HPA specification. With this modulation method spectral bands may simply be turned off as they are done with the HPA standard version 1.0. Future modulation schemes could define more carriers and even closer carrier spacing, allowing tighter control over larger frequency spans.

Reply:
If BPL is restricted to frequencies not less than 200 KHz from victim allocations, it will not be usable at all. Frequency masking thus shows itself more an expedient than a reliable protection. Moreover, the ARRL notes that in its cooperative testing with HomePlug, while masking was sufficient to protect Amateur Radio operation with antennas some distance from the dwelling, it would not be enough to protect reception using closer and smaller antennas such as consumers and many Amateurs must use. .

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The writer desiring that the Commission examine PowerComm' Reply Comments with the above in mind, these remarks are respectfully submitted.

Cortland E. Richmond, Jr., KA5S

20 August 2003